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SHOCK DEVELOPMENT PRIOR TO DETONATION IN SHAPED LAYERED NONLINE--ETC(U)
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Shock Development Prior to Detonation in Shaped Layered Nonlinear Elastic Media

With Stochastic Variability

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by

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The objective of this work was to examine the way in which an acceleration wave propagates in a randomly layered nonlinear medium in which the material constants vary stochastically from layer to layer. Furthermore the problem, although formulated as a one-dimensional configuration, was modified to describe propagation in a bar in which there is a slowly changing cross-sectional area. Thus the analysis may be applied to formed charges which have an axis of symmetry and a slowly varying cross-section normal to that axis.

Propagation was assumed to be normal to the layering and along the axis of symmetry, while both the material constants and the layer thicknesses were regarded as stochastic variables. The time and place of shock wave formation was found and, for the purposes of this analysis, were taken to be synonymous with the time and place of the initiation of detonation.

Apart from the complication in the expressions for the transmission and reflection coefficients at each interface and in the transport equations, the main effect of the area variation was found to be the introduction of an oscillatory rather than a monotone behaviour for the propagating acceleration wave in each layer. In the one-dimensional approximation that was used, this corresponds to diffraction effects introduced by the variable cross-sectional area. It is possible that under some circumstances this oscillation might precipitate shock formation relative to the constant cross-sectional area case, and hence precipitate detonation.

As already mentioned, the stochastic variability of the medium is taken to be introduced via the mechanism of an arbitrary layering in which both layer thickness and material constants are assumed to be sampled fromgiven, but otherwise arbitrary, distributions. For this reason the layer thicknesses were assumed to be small, though this assumption introduced no approximation in the wave transport analysis.

To find the statistical distribution of the position of shock formation that results, or a confidence interval for the acceleration wave intensity, numerical methods would be necessary, based on the analytical results just outlined. The

preliminary analysis for this work was described in (1) and the rest in (2).

In the future this work will be continued in a slightly different way by examining the effect of a reaction rate equation in which the rate constant is a stochastic variable, and in which there may also be a source term present that could be either determinate or stochastic. In its simplest form this would involve finding the moments and correlation functions for the equation

$$\frac{dy}{dt} = -K(t)y + L(t) \qquad \text{with } y(0) = 1,$$

where $K(t)$ is a random function defined to be

$$K(t) = K_1 \quad \text{with probability } p > 0$$

and

$$K(t) = K_2 \quad \text{with probability } q > 0,$$

with $K_1 \neq K_2$, $p + q = 1$ and $L(t)$ some source function. Only the case $p = q = \frac{1}{2}$ is to be found in the literature, though there it is mainly second order equations that are involved. The subsequent generalisation would then be to consider a function

$$K(t) = K_i \quad \text{with probability } p_i > 0 \text{ for } i = 1,2,\ldots,n,$$

where

$$p_1 + p_2 + \ldots + p_n = 1 \text{ and the } K_i \text{ all different.}$$

References

1. A.Jeffrey, Stochastic variability in the initiation of detonation, Applied Mathematics Institute, University of Delaware Report#59A1978.

2. A.Jeffrey and R.P.Gilbert, Shock development prior to detonation in a shaped layered nonlinear elastic medium with stochastic variability, Applied Mathematics Institute, University of Delaware Report #67A,1979.

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